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Green blue infrastructure at metropolitan scale: a water sustainability approach in the Metropolitan Region of Belo Horizonte, Brazil

Les infrastructures vertes et bleues à l'échelle métropolitaine : une approche de la gestion durable de l'eau dans la région métropolitaine de Belo Horizonte (Brésil)

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RÉSUMÉ

Cet article décrit les résultats préliminaires d'un projet de recherche en cours qui a comme objectif d'examiner si les infrastructures vertes et bleues (IVB) peuvent être considérées comme un moyen efficace pour la protection des milieux aquatiques et pour le retour vers un cycle plus naturel de l'eau dans une région métropolitaine. Il vise à évaluer les bénéfices qui peuvent être obtenus par une approche IVB en termes hydrologiques, écologiques et urbanistiques dans le but de protéger les lacs et les réservoirs important à l'échelle métropolitaine. Le projet de recherche porte sur la région métropolitaine de Belo Horizonte (RMBH), au Brésil, une grande agglomération pour laquelle un processus de planification stratégique est en cours d'élaboration depuis 2010. Les résultats obtenus par une analyse préliminaire des caractéristiques et de l'occupation des sols d'un bassin versant ainsi que d'une proposition de mise en œuvre d'IVB sont présentés et discutés brièvement.

ABSTRACT

This paper describes preliminary results of an on-going research project aiming at investigating whether Green Blue Infrastructure (GBI) implementation may be considered as an effective way to protecting water bodies and to recover the natural water cycle in a metropolitan region. It focuses on assessing the benefits that may be provided by a GBI approach in hydrological, ecological and urbanistic terms with the aim of protecting lakes and reservoirs that are relevant at a metropolitan scale. The research project focuses on the Metropolitan Region of Belo Horizonte (RMBH for the acronym in Portuguese), in Brazil, a large conurbation for which a strategic planning process is being developed since 2010. Results from a preliminary application of GIS analysis of catchment characteristics and land use patters as well as a proposal for GBI implementation are presented and briefly discusses.

KEYWORDS

Green blue infrastructure, land use classification, metropolitan areas, retrofitting green blue infrastructure in built areas, urban water management

1 INTRODUCTION

Green infrastructure is frequently reported as an approach able to decisively contribute to the sustainability of urban water management (Maes et al., 2014). The same can be stated for the emerging concept of green blue infrastructure (GBI). Although the understanding of green-blue approaches may vary regionally, it usually refers to the association of urban water management concepts such as water sensitive urban design (WSUD) and low impact development (LID with more regional approaches encompassing blue green corridors providing connectivity between protected areas and promoting biodiversity, among other functions. GBI is, therefore, a new concept that aims to protect the environment, both the “green” (e.g. trees, grass, bushes, etc.…) and the “blue” (e.g. ponds, creeks, lakes, reservoirs, rivers, etc.). In practice, it is an interconnected network of natural and artificial green spaces and water-bodies, within and between urban areas.

GBI seems to be perfectly adequate for use in metropolitan regions where a considerable variety of land uses occurs, including highly dense urban as well as low-density peri-urban areas, industrial and agricultural land uses, natural parks and reserves, big reservoirs, etc. In this kind of environment, GBI can play an important role for the protection of water resources and the mitigation of at least part of the environmental impacts due to urbanisation, industrial and agricultural activities, among others.

In a metropolitan region, GBI may play other important roles such as:

- Protecting areas of particular environmental interest at metropolitan scales as it is the case of catchments which are strategic for the production of drinking water;
- Reducing natural risks as flooding and land sliding;
- Mitigating environmental impacts of agricultural, industrial and mining activities;
- Mitigating impacts of urbanization on the local climate, as it is the case of heat islands, through a considerable increase on the presence of threes and green spaces in urban areas;
- Promoting connectivity, integrating urban and protect areas within metropolitan regions;
- Restoring and protecting riparian areas, water sources and recharge areas and steep hilltops;
- Promoting biodiversity by improving the ecological state of urban and metropolitan areas and recovering ecological continuity.

Nevertheless, one of the main challenges of adopting GBI approaches relates to the fact that the core of metropolitan areas is frequently composed by already built and densely occupied urban areas (e.g.: Romnée et al, 2015; Baek et al, 2015). Actually, when it comes to adopting green blue strategies in a metropolitan scale, large cities may be seen as territorial discontinuities in a network of blue green corridors connecting protected areas and other land uses of high environmental interest.

Particularly in the developing world, existing water infrastructure has frequently been built according to conventional approaches. This leads to low adaptability in a changing world where pressures due to climate change and population growth as well as positive socioeconomic evolutions such as a more balanced income distribution followed by demands for quality of life improvements require more flexible and adaptable approaches on urban development and natural resources management.

The present extended abstract describes preliminary results of an on-going research project aiming at investigating whether GBI implementation may be considered as an effective way to protecting water bodies and to recover the natural water cycle in a metropolitan region. It focuses on assessing the benefits that may be provided by a GBI approach in hydrological, ecological and urbanistic terms with the aim of protecting lakes and reservoirs that are relevant at a metropolitan scale. The research project focuses on the Metropolitan Region of Belo Horizonte (RMBH for the acronym in Portuguese), in Brazil, a large conurbation for which a strategic planning process is being developed since 2010.

2 MATERIAL AND METHODS

In this topic, we briefly describe the methods adopted in this research project and case studies.

2.1 Case studies

Belo Horizonte (BH) is an important hub in the mining and steel industry fields for the entire Brazil. Located in the South East region of the country, along with Sao Paulo and Rio de Janeiro, it belongs to the economic and industrial Brazilian triangle. Designed to be the capital of the state of Minas Gerais, the construction of BH began just at the end of the nineteenth century. The metropolitan

region of Belo Horizonte (RMBH), actually formed by 34 municipalities, has an area of 9,179 km^2 and gathers 5,800,000 inhabitants whose 2,500,000 are dwellers of its largest city, Belo Horizonte (IBGE 2014). This research is conducted through two case studies in the RMBH involving two catchments and three municipalities: Pampulha catchment (100 km^2) and Vargem das Flores catchment (120 km^2), both located over two municipalities (Figure 1).



Figure 1. The Pampulha and Vargem das Flores catchments with the respective reservoirs (Source: Granceri et al, 2015).

The methodological approaches is based on a set of integrated tools including land use assessment through GIS, catchment hydrological modelling and ecological modelling of lakes and reservoir (Figure 2) .A fourth dimension also considered, the social one, focuses on participation processes aiming at building up together a scenario of GBI validation and implementation.

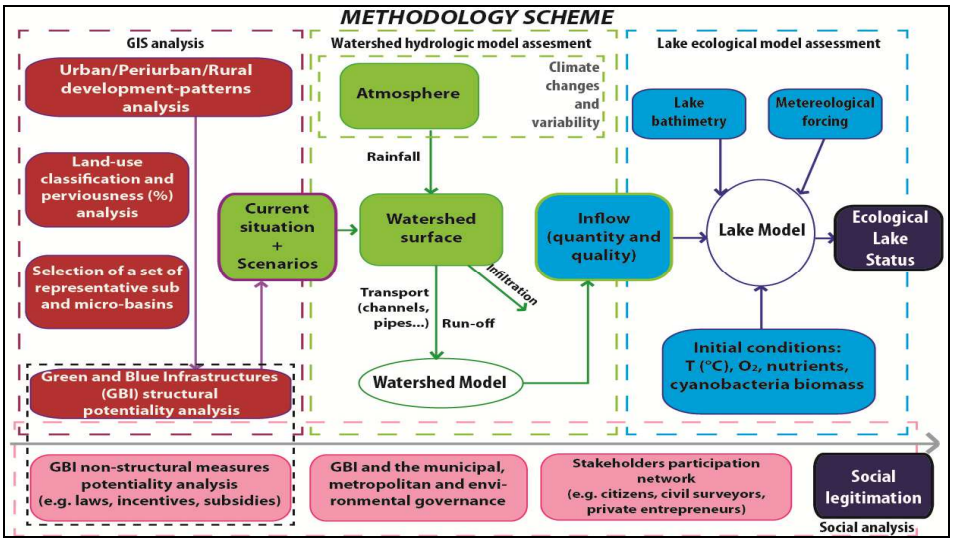


Figure 2. The Methodology scheme.

The GIS analysis, based on a detailed cartographic dataset, is a key aspect in terms of landscape ecology, land use and hydrological analysis and as a tool to be employed in collaboration with stakeholders. Land use (LU) is assessed for the whole catchment territory, classifying it according to categories, knowing that some combinations of these categories may possibly exist. Parameters such as lot size, impervious surface, building typology (houses, apartment buildings) and vegetation cover, road categories and others allow identifying and gathering similar land use patches. Other land characteristics (topography, depth of the water table, etc) make it possible to identify types of GBI that can be implemented for each LU patch.

The GIS assessment phase combined with literature review, field visits and participatory processes lead to the conceptualization of three scenarios that will be the base of the hydrological and ecological modelling processes, as follows:

a) Scenario 0: refers to the current environmental status of the case study catchments. It is the base for the calibration and validation of the hydrological and ecological models.

b) “Business as usual” scenario represents a conventional approach on land use and water

management in the catchments as stated in the current municipal land use regulations.

c) GBI scenario corresponds to the adoption in the catchment case studies of the GBI approach.

For the hydrological modelling we selected the XP Solution version of the Stormwater Management Model (Rossman, 2007), the XP-SWMM. The physical and ecological modelling of Lake Pampulha and the Vargem das Flores reservoir are performed according to (Silva et al., 2015).

GBI objectives, as stated in the introduction are quite large and probably difficult to be achieved all together at local scale. Additionally, it is relevant to highlight that in a large metropolitan area, the diversity of catchment physical characteristics, ecological state and land uses imply that GBI priorities will vary according to local conditions. The present project mainly focuses on the protection of strategic sources for drinking water supply at metropolitan scale, contributing to runoff and diffuse pollution abatement and to recovering, as much as possible, the former natural water cycle. Flood control is also a strategic objective for many of the RMBH catchments, considering that reducing flood risk is an important target in itself and may decisively contribute for GBI acceptance by the population, in general, For each catchment in the RMBH, GBI objectives will be more precisely stated through the diagnoses provided by the scenario 0, previously described, combined with the assessment of catchment characteristics, land use and urban patterns which will allow to devise the more suitable GBI devices to be implemented. The GBI alternatives will then be submitted to the participatory process in order to select those that may be of higher acceptance.

The participatory process with stakeholders will be structured in different phases which will include (i) the selection of participants among developers, civil society representatives, urban planners and other staff members of the city halls, city council representatives…, (ii) the assessment on their former knowledge about GBI and on their perception of the environmental qualities and problems of the case studies and (iii) detailed and iterative discussions on GBI alternatives to face those problems.

3 RESULTS AND DISCUSSIONS

In this topic, we briefly describe and discuss partial results obtained for the Ressaca catchment, a sub-catchment of the Pampulha stream catchment and direct tributary to Lake Pampulha. These results focus on physical and land use assessments and on preliminary proposals for GBI adoption in this area. Figure 3 illustrates the analysis performed in this catchment encompassing topography and hydrography (Fig. 3 a) and urban fabric and open spaces (Fig. 3 b). Figure 3 c is a result of combining the topographic and the urban fabric maps is order to elaborate a preliminary proposal for LU classification and GBI implementation in this area. With the exception of green areas, this catchment is densely and fully occupied by residential and commercial areas. Most of the streams in the catchment are lined and culvert. Therefore, fully applying GBI concepts in this area leads to proposals for stream recovery as well as the adoption of a variety of LID devices, illustrating the challenges of retrofitting this kind of infrastructure in a built environment.

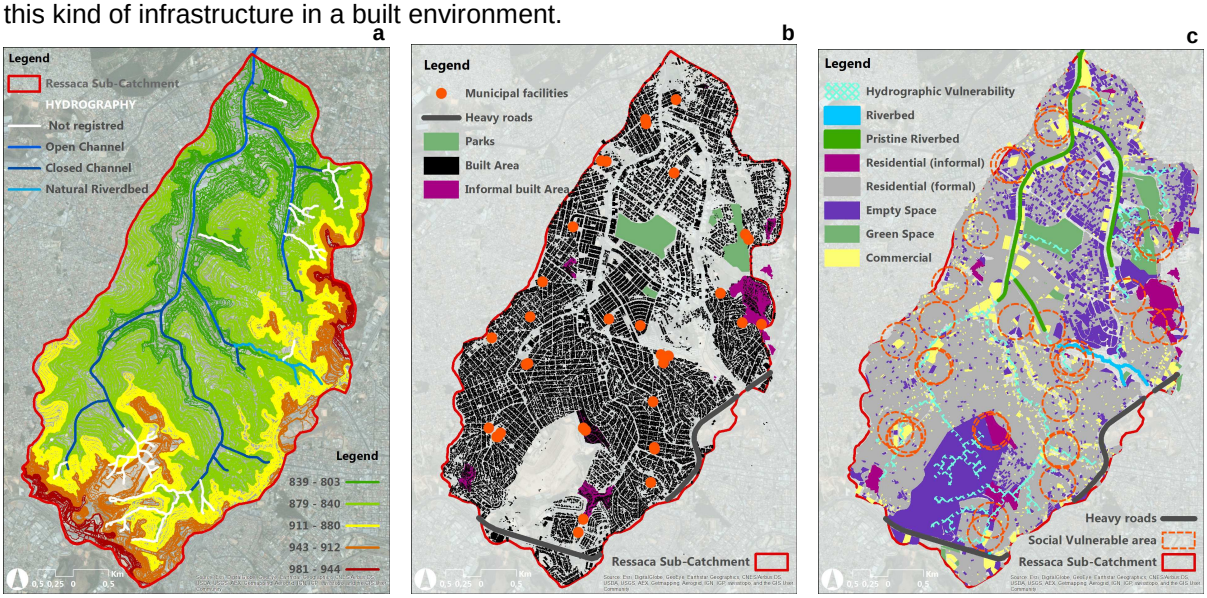


Figure 3. Ressaca creek catchment: (a) Topography and hydrography; (b) Urban fabric; (c) LU classification

In Table 1, one can find a suggested of GBI strategies that would be implemented in this area. Land use is classified in 8 different categories. According to the sub-catchment characteristics, some of these categories may also overlaps (i.e. Vulnerable Social Areas, Hydrographic Vulnerable Area, Pristine Riverbed). This overlapping layers aim to highlight those areas where people and the natural environment cycle should be protected and managed with more sensitivity. This predominant characteristic put the challenge of GBI implementation in the vision of retrofitting.

Table 1. Ressaca creek catchment: proposed GBI

LU CLASS \ GBI	Bioswale	Green Roof	Porous Pavement	Arborization	River Revitalization
Hydrographic Vulnerabile Area	+++	/	++	+++	+++
Riverbed protection	++	/	++	+++	+++
Pristine riverbed area	++	++	++	+++	+
Empty space - new developments	++	+++	+++	++	/
Heavy traffic Road	+++	/	++	+++	/
Residential (formal) Area	++	+-	+++	++	/
Residential (informal) Area	-	++	-	+++	+
Vulnerable Social Area	+	++	++	+++	+

(Legend: +++ highly recommended; ++ recommended; + can be employed; - not recommended; / not pertinent)

Next steps will include modelling of current, business as usual and GBI scenarios as well as meeting with stakeholders to assess and debate about viability and acceptability of the suggested GBI interventions.

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LIST OF REFERENCES

Baek, S.-S., Choi, D.-H., Jung, J.-W., Lee, H.-J., Lee, H., Yoon, K.-S., Cho, K. H. (2015*). Optimizing low impact development (LID) fir stormwater runoff treatment in urban area, Korea: Experimental and modelling approach*. Water Research 86, 122-131.

Granceri, M., Vinçon-Leite, B., De Gouvello, B., Moura, H. C. S., Silva, T., Nascimento, N. O., (2015*). Sustainable management of water resources in metropolitan areas. Which role for Green and Blue Infrastructures in the Brazilian metropolitan region of Belo Horizonte?* In: Proceedings of the Water, Megacities and Global Change Conference, Paris: ARCEAU and UNESCO.

IBGE (2014). *Anuário Estatístico do Brasil. Instituto Brasileiro de Geografia e Estatística, Rio de Janeiro, Brasil*, 458 p.

Maes, J., Barbosa, A., Baranzelli, C., Zulian, G., Silva, F. B., Vandecasteele, I., Lavalle, C. (2014). *More green infrastructure is required to maintain ecosystem services under current trends in land-use change in Europe*. Landscape Ecology, *30*(3), 517–534. http://doi.org/10.1007/s10980-014-0083-2

Romnée, A., Evrard, A., Trachte, S. (2015). *Methodology for a stormwater sensitive urban watershed design*, Journal of Hydrology, 530, 87-102.

Rossman, L. A. (2007), *Storm Water Management Model User's Manual*, EPA/600/R-05/040, U.S. EPA.

Silva, T. (2014). *Suivi et modélisation de la dynamique des cyanobactéries dans les lacs urbains au sein de leur bassin versant* (phdthesis). Université Paris-Est. Retrieved from https://hal-enpc.archives-ouvertes.fr/tel-01079000/document